Experimental Investigation Of Various Minor Losses By Using Bourdon Pressure Gauge

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Abstract- *The term "minor losses", used in many textbooks for head loss across fittings, can be misleading since these losses can be a large fraction of the total loss in a pipe system. In fact, in a pipe system with many fittings and valves, the minor losses can be greater than the major (friction) losses. Thus, an accurate K value for all fittings and valves in a pipe system is necessary to predict the actual head loss across the pipe system. K values assist engineers in totaling all of the minor losses by multiplying the sum of the K values by the velocity head to quickly determine the total head loss due to all fittings. Knowing the K value for each fitting enables engineers to use the proper fitting when designing an efficient piping system that can minimize the head loss and maximize the flow rate. The objective of this experiment is to determine the loss coefficient (K) for a range of pipe fittings, including several bends, a contraction, an enlargement, and agate valve. In our Capstone project work our main objective is to replace the manometer which is available in the experimental set up by pressure gauges for the accurate reading and further calculations. So that the effectiveness and reliability in the performance of the test ring must be improved in comparison with the manometer.*

Keywords- minor losses, pipe fittings, pressure gauge.

I. INTRODUCTION

Two types of energy loss predominate in fluid flow through a pipe network; major losses, and minor losses. Major losses are associated with frictional energy loss that is caused by the viscous effects of the medium and roughness of the pipe wall. Minor losses, on the other hand, are due to pipe fittings, changes in the flow direction, and changes in the flow area. Due to the complexity of the piping system and the number of fittings that are used, the head loss coefficient (K) is empirically derived as a quick means of calculating the minor head losses.

For flow in a circular pipe, an expression for the head loss due to skin friction can be developed by applying the principles of conservation of energy and linear momentum. The expression that results for pipe-head loss hf is

$$h_f = \frac{f\, l\, v^2}{2gd} \quad ....(1)$$

where: f = Darcy friction factor V = average flow velocity L = pipe length g = acceleration due to gravity d = pipe inside diameter

Equation 1, known as the Darcy-Weisbach equation, is valid for duct flows of any cross section and for either laminar or turbulent flow. The Darcy friction factor is a function of both the Reynolds number and the pipe relative roughness

$$f = F\left(R_{ed,} \frac{\varepsilon}{d}\right) = \frac{8\tau_w}{\rho V^2} \quad ......(2)$$

where Red = Reynolds number based on inside diameter ε= absolute roughness , τ_w = shear stress at the pipe wall, ρ = fluid density

II. LITERATURE SURVEY

A literature survey represents a study of previously existing material on the topic of the report. This includes (in this order) -

- Existing theories about the topic which are accepted universally.
- Books written on the topic, both generic and specific.
- Research done in the field usually in the order of oldest to latest.
- Challenges being faced and ongoing work, if available.

The literature survey should be structured in such a way as to logically (and chronologically) represent the development of ideas in that field.

Lahioel Yasminaa, Lahiouel Rachidb [1], In their paper they described that, Energy losses in pipes used for the transportation of fluids (water, petroleum, gas, etc.) are essentially due to friction, as well as to the diverse singularities encountered. These losses are usually converted into head reductions in the direction of the flow. The knowledge of data of such transformation allows the determination of the necessary power needed for the transportation of the fluid between two points. It constitutes the necessary calculation basis necessary for the design and analysis of transport and distribution networks. The review of the different relationships allowing the determination of these losses and their comparison to the experimental results obtained by the authors constitute the object of this study.

Seroor Atalah Khaleefa Ali , Dr, Huda T.Hamad [2], In their paper they presented that, Pressure losses are very important factories that effects on the flow in piping systems where concludes different length of pipes, diameters, fittings, elbows and valves. In this study water was used as a working fluid at room temperature and physical properties water was used. Different actual and theoretical pressure losses were studied and compared. Pressure drop measurement and prediction in curved pipes and elbow bends is reviewed for both laminar and turbulent single-phase fluid.

Amol V. Narayane, Vivek C. Pathade. Vikram Roy [3], In their paper they carried discussion that, The numerical analysis of the turbulent fluid flow through an axi-symmetric sudden expansion passage has been carried out by using modified kepsilon model, taking into consideration the effects of the streamline curvature. The variations of the size and strength of the recirculation bubble for different Reynolds numbers and expansion ratios have been analyzed. The recirculation bubble generated due to the sudden expansion of the passage is observed to reduce in size and strength with the increase in the Reynolds number. But the size and strength of the recirculation bubble increases with the increase in the expansion ratio. The radial distributions of the turbulent energy and the axial velocity have been obtained.

Amol V. Narayane, Vivek C. Pathade. [4], In their paper study perform a numerical investigation has been done to analyze the turbulent fluid flow through a sudden expansion. It has been observed that the recirculation bubble exist in twin structures. The primary recirculation bubble was observed to increase by the increment of the expansion ratio. However the reattachment length is observed to vary in a complex way; increases at first with the Re then it decreases gradually with respect to Re. It has been observed from the variation of Cf that the recirculation with a flow having less inlet velocity and intensity of turbulence is much smaller than in the fully turbulent flow with considerably higher inlet velocity as well as turbulence intensity. It is also concluded that strength of the recirculation bubble is increased with the expansion ratio, keeping Re constant.

F. W. Ntengwe, M. Chikwa, L. K. Witika. [5], In their paper, diameters of pipes ranged from 25 to 100 mm while the process fluid flow rates ranged from 0 to 50 m3 /h. The Darcy-Weisbach, Hazen-Williams and Poisselli’s methods were used to evaluate friction losses. The results showing increasing D of the pipe and decreasing the hL in the pipe line, gate valve, 45o and 90o elbow, entry and exits to pipes are presented. The results of increasing Q with increasing exponential values of hL regardless of D of pipe also presented. Therefore, a number of choices can be made between transporting process fluids using small D pipes (50>D>25 mm) and Reynolds (Re) numbers in the laminar region and large D pipes (100>D>50 mm) using Re numbers in turbulent regions.

Pondok Pesantren Tahfizhul Qur'an Ibnu Abbas Tarakan [6],. The stages taken are; literature review by reviewing several previous studies then continued with data collection on the piping system in Ibnu Abbas Tarakan Islamic Boarding School. The discussion of head losses in the piping system is divided into four parts according to the existing branching of the pipe installation when the water comes out of the pump. Head losses in each section, namely; the first section (A) 0.21 m, the second section (B) 0.47 m, the third section (C) 0.3 m. Whereas in the fourth section, the existing pipe installation is not supplied by water when the water flow from the pump is distributed simultaneously in the four existing pipe branches. The pump is unable to serve the existing pipe installation, if it is flowed simultaneously.

From the above literature survey we learned about the previous work carried out by the researcher’s, scholars, students in the field of hydraulics and pipe fittings.

III. METHODOLOGY OF PROJECT

This methodology can be adapted to study the minor losses associated with various components and configuration within a fluid system. In addition to the loss of head caused by friction in a pipeline, there are losses due to change in the cross-section and presence of bends, valves and different kinds of fittings. In a long pipeline these additional losses (usually termed minor losses) may be a small fraction of the ordinary friction loss and hence, are considered negligible in long pipelines. The minor losses may, however, exceed the frictional losses in a shorter pipeline and should, therefore, be accounted for in such situations. These minor losses are generally caused due to sudden changes in the magnitude and or direction of the velocity of flow. So, this project is about to analysis the various minor losses accurately by using pressure gauges instead of manometer.

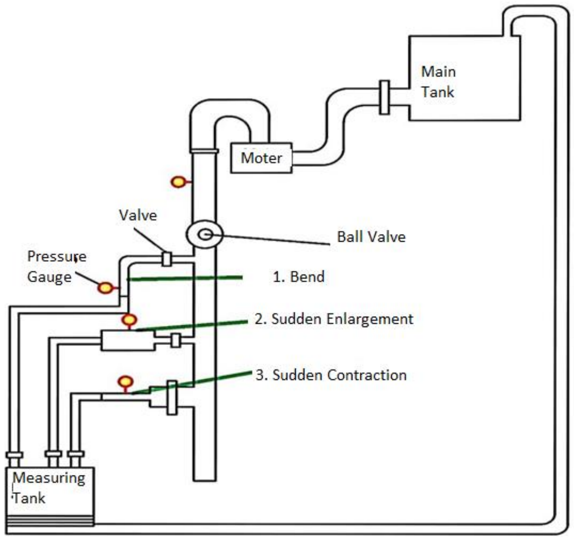

Fig. Experimental Set Up

IV. EXPERIMENTAL PROCEDURE

Fig. Actual Experimental Setup

Experimental Procedure

1. Open the delivery valve of centrifugal pump.
2. Carry out priming of pump if necessary.
3. Adjust inlet & outlet valve such that 'sudden enlargement arrangement' of pipe is only connected.
4. Start the pump which allows water to flow through Storage tank.
5. Adjust the discharge by control valve stop valve and ensure steady flow in system.
6. Note the reading from pressure gauge at inlet and outlet.
7. Collect water in a measuring tank to measure the actual discharge for 10 seconds (or suitable for setup).
8. Use stop watch to measure time “T”.
9. Drain the water collected in the measuring tank after each observation.
10. Adjust inlet & outlet valve such that 'sudden contraction arrangement' of pipe is only connected.
11. Repeat the step 4 to 7 for when 'sudden contraction arrangement' is connected in system.
12. Adjust inlet & outlet valve such that 'Elbow fitting' in the pipe is only connected.
13. Repeat the step 4 to 7 for when Elbow fitting "is connected in system.
14. Adjust inlet & outlet valve such that Bend fitting 'in the pipe is only connected.
15. Repeat the step 4 to 7 for when Bend fitting is connected in system.

V. OBSERVATION

Discharge Measurement reading
Measuring tank Dimension = Diameter (D) = 0.28m
Time required for collecting water = 10 seconds.

For Sudden enlargement:
Diameter of pipe at entry, d_1 = 0.0246m
Diameter of pipe at enlargement, d_2, = 0.0345m

For Sudden Contraction:
Diameter of pipe at entry. d_1 =0.0246m
Diameter of pipe at contraction, d3 = 0.0158

Bend:
Angle of bend 90, diameter of pipe, $d_{1=}$ 0.0246

Calculation of discharge measurement reading:
Head available at inlet (H_1)= 5 m = Constant

Observation Table.

Sr. No.	**Nature of pipe fitting**	**Inlet & Exit diameter of pipe**		**Pressure Gauge Reading**	
		Inlet (m)	**Exit (m)**	**Inlet P_1**	**Outlet P_2**
1.	Sudden Enlargement	0.0243	0.0345	0.5	0.4
2.	Sudden Contraction	0.0243	0.0158	0.5	0.2
3.	Bend	0.0243	0.0243	0.5	0.3

Sr. No.	Head Reading		Actual Head loss in meters of water column (H_1-H_2)	Rise of Water Level of measuring tank in 10 Sec.
	Inlet H_1	Outlet H_2	m	m
1	5	4	1	0.17
2	5	2	3	0.145
3	5	3	2	0.10

VI. CALCULATIONS

Case 1: Loss of Head due to sudden enlargement

Head available at outlet= $H_2 = \frac{P2}{W_w} = \frac{(0.4\times10^4\times9.81)}{9810} = 4$ m

Actual loss of head due to sudden enlargement

Hact$_2$= (H_1-H_2)= (5-4)= 1 m

Actual discharge = $Q_{act} = \frac{volume\ of\ water\ collected}{time} = \frac{\pi r^2\ h}{t}$

$Q_{act} = \frac{\pi 0.14^2\times0.17}{10} = 1.04\times10-3$ m^3/sec

Velocity of water at entry V1 = $\frac{Q}{A1}$

A1 = $\frac{\pi}{4}\times d_1^2 = \frac{\pi}{4}\times(0.0246)^2 = 4.75\times10^{-4}$

V1 = $\frac{Q}{A1} = \frac{1.04\times10^{-3}}{4.75\times10^{-4}} = 2.18$ m/s

Velocity of water at outlet V2 = $\frac{Q}{A2} = \frac{1.04\times10-3}{9.4\times10^{-4}} = 1.16$ m/s

Theoretical loss of head due to sudden enlargement

$H_e = \frac{(V1-V2)^2}{2g} = \frac{(2.18-1.16)^2}{2\times9.81} = 0.053$ m of water.

Case 2: loss of head due to sudden contraction

Head available at outlet= $H_3 = \frac{P3}{W_w} = \frac{(0.2\times10^4\ 9.81)}{9810} = 2$m

Actual loss of head due to sudden enlargement Hact$_2$= (H_1-H_3)= (5-2)= 3 m

= $Q_{act} = \frac{volume\ of\ water\ collected}{time} = \frac{\pi r^2\ h}{t}$

$Q_{act} = \frac{\pi\times0.14^2\times0.145}{10} = 8.92\times10^{-4}$ m^3/sec

Velocity of water at entry $V_1 = \frac{Q}{A1}$

A1 = $\frac{\pi}{4}\times d1^2 = = \frac{\pi}{4}\times(0.0246)^2 = 4.75\times10^{-4}$

$V_1 = \frac{Q}{A1} = \frac{8.92\times10^{-4}}{4.75\times10^{-4}} = 1.87$m/s

Velocity of water at outlet V2 = $\frac{Q}{A2} = \frac{8.92\times10^{-4}}{9.4\times10^{-4}} = 0.9498$ m/s

Theoretical loss of head due to sudden enlargement

$H_e = \frac{(V1-V2)^2}{2g} = \frac{(1.87-0.949)^2}{2\times9.81} = 0.046$ m of water

Case 3: Bend

Head available at outlet= $H_4 = \frac{P4}{W_w} = \frac{(0.3\times10^4\ 9.81)}{9810} = 3$ m of water

Actual loss of head due to sudden enlargement

Hact$_2$= (H_1-H_4)= (5-4)= 2 m

Actual loss of head due to bend Hb_{act} = 2m of water

$Q_{act} = \frac{volume\ of\ water\ collected}{time} = \frac{\pi r^2\ h}{t}$

$Q_{act} = \frac{\pi 0.14^2\times0.1}{10} = 6.15\times10^{-4}$ m^3/sec

Theoretical loss of head due to bend = $H_b = \frac{k\times V\ 4^2}{2g} = \frac{0.45\times1.29^2}{2\times9.81}$ = 0.038 m of water

Velocity of water following through bend = $V_4 = Q/A_4$ = 1.29 m/sec

Equating actual loss of head = Theoretical loss of head

$H_b = \frac{k\times V\ 5^2}{2g} = \frac{0.45\times1.29^2}{2\times9.81} = 0.038$ m of water

K = 0.45

VI. RESULTS & DISCUSSION

Case1: For sudden enlargement

Actual loss of head = 1 m of water

Theoretical loss of head = 0.053 m of water.

Case2: For sudden Contraction

Actual loss of head = 3m of water

Theoretical loss of head = = 0.046 m of water

Case 3: or bend

Actual loss of head = 2 m of water

Theoretical loss of head = 0.038 m of water.

The above results are just varying while comparing to standard values. The experimental set up is quite adequate to give the readings

VII. CONCLUSION

The term 'pipe' is a closed conduit used to carry liquids under pressure. Pipes are commonly circular in section, because of advantage of structural strength with that of structural simplicity. Pipes of same sectional area but of different shape, circular shape is having smallest perimeter of section and smallest inside wall area per unit length. Therefore resistance offered by circular pipe to flow the liquid through it is less than in a pipe of any other sections. When liquid is flowing through a pipe there is relative motion between the layers of moving water and between layers and pipe walls. Due to this relative motion, there exists always resistance to fluid flow. Therefore driving force is necessary to balance this resistance and maintain the flow of fluid. This resistance offered by fluid to flow is known as frictional resistance. When a liquid is flowing through a pipe, the liquid experiences some resistance due to which some of the energy of liquid is lost. From the above experiment we conclude that the pipe fitting leads into the friction losses and we are setting less discharge as expected for given pipeline design system.

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